Registration of Four Pima Cotton Germplasm
Lines Having Good Levels of Fusarium Wilt Race 4
Resistance with Moderate Yields and Good Fibers

M. Ulloa,* R. Percy, Jinfá Zhang, R. B. Hutmacher, S. D. Wright, and R. M. Davis

ABSTRACT

Four Pima cotton (Gossypium barbadense L.) germplasm lines, SJ-07P-FR01 (Reg. No. GP-910, PI 654065), SJ-07P-FR02 (Reg. No. GP-911, PI 654066), SJ-07P-FR03 (Reg. No. GP-912, PI 654067), and SJ-07P-FR04 (Reg. No. GP-913, PI 654068), were developed by the USDA–ARS and New Mexico State University Agricultural Experiment Station and jointly released with the University of California in 2008. The primary purpose for these releases is to provide germplasm with good levels of resistance to Fusarium wilt [Fusarium oxysporum f. sp. vasinfectum Atk. Sny & Hans] (FOV) race 4 to cotton breeders in California. The lines were evaluated for resistance to race 4 in two field and three greenhouse trials conducted in 2003 and 2005. Five replicated field evaluations for yield potential, fiber characteristics, and other agronomic traits were conducted at Five Points, CA, Shafter, CA, and Maricopa, AZ, in 2005 and 2006. The SJ-07P-FR series possesses good resistance, moderate lint yield potential, and good to superior fiber length and strength. Caution should be applied when using these lines, and it should not be assumed that the lines provide complete resistance against FOV race 4.

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resistance has proven to be the most effective means of managing this disease. Before the release of SJ-07P-FR01, -FR02, -FR03, and -FR04, resistance to race 4 had been identified in a very restricted genetic base among commercial cultivars in California (Hutmacher et al., 2005; Ulloa et al., 2006). The primary purpose for releasing SJ-07P-FR01, -FR02, -FR03, and -FR04 is to provide germplasm with good levels of resistance to FOV race 4 and provide private and public breeders with sources of FOV resistance gene(s).

Methods
SJ-07P-FR01, SJ-07P-FR02, and SJ-07P-FR03 lines originated from a cross of germplasm lines 8810 and NMSI 1601. Line 8810 possesses superior fiber strength and high yield potential when grown in the high temperatures of the far western United States (Percy, 1998). Line 8810 was developed from a cross between P 73 × P 72. The P 73 parent of 8810 was developed from the cross P 53 × PS 6 (Percy and Turcotte, 1997). NMSI 1601 was developed by New Mexico State University Agricultural Experiment Station from a single plant selection within an open-pollinated synthetic population originating from Monseratt Sea Island, and it possesses excellent fiber length and fineness. SJ-07P-FR01 -FR02, and -FR03 germplasm lines originated from New Mexico State University at Las Cruces, NM, in 1997. Initial individual plant selection within the hybrid population was conducted in the F2 to F4 generations at Las Cruces, NM. A final series of individual plant selections was conducted in the F4 generation at Shafter, CA, from progeny rows. Subsequent generations for each line were advanced as individual progeny to obtain enough seed for replicated trials. SJ-07P-FR04 is a population originating from reselection within P 73. A series of individual plant selections was conducted on P 73 at the University of California West Side Research & Extension Center, Five Points, CA, and the Shafter Research & Extension Center, Shafter, CA. Two recurrent selections were applied for morphological uniformity such as plant height, leaf shape, petal spot, yield, and fiber properties. Phenotypically, the SJ-07-FR lines resemble typical Pima cottons with mid- to late maturity.

The lines were evaluated for resistance to FOV race 4 in two field trials conducted in 2003 and 2004 and in three greenhouse trials conducted in 2004 and 2005. Evaluations were performed on generations F3, F4, and F5 that were handled as populations. The lines were planted in fields known to be infested with FOV race 4. Plants in these fields consistently developed severe Fusarium symptoms (inoculum levels were unknown and varied from year to year). Lines were grown in one-row plots 5-m long with 1-m row spacing in a randomized complete block design with three replications in 2003 and 2004. For greenhouse evaluations, germplasm lines were seeded into a composite medium of vermiculite and peat moss before inoculation. Roots of 2- to 4-wk-old seedlings were gently washed to remove most of the soil medium. Then roots were dipped in water (nontreated plants as a control) or spore suspension of 1 × 106 conidia mL−1 of water for 2 min (treated plants). Inoculum for pathogenicity testing was obtained by placing a 25-mm2 piece of filter paper cultured with single spores on a potato dextrose agar (PDA) in 15-mL petri dishes for 2 wk. Spore suspensions were prepared by flooding colonized 2-wk-old cultures on PDA with water, scraping off the spores, and filtering the spore suspension through four layers of cheesecloth (Ulloa et al., 2006). After inoculation, plants were individually transplanted to pots filled with the composite medium. The experiment was a complete randomized design with five replications. Each replication was represented by 1 plant pot−1. The data presented in Table 1 were extracted from experiments with about 40 cultivars for greenhouse and about 80 cultivars for field. Cultivars were used as treatments for the statistical analyses. To determine the level of tolerance or resistance for each line, all plants were assayed at 4 to 6 wk after inoculation for foliar symptoms, vascular stain or brown

Table 1. Field and greenhouse evaluations of the performance of Pima cotton: foliar symptoms (F damage), vascular stain (V stain), number of nodes, and plant height.

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>F damage†</th>
<th>SE</th>
<th>V stain‡</th>
<th>SE</th>
<th>Node no.</th>
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<th>Plant height</th>
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Five replicated field evaluations of the lines for yield potential, fiber characteristics, and other agronomic traits were conducted at West Side and Shafter, CA, and Maricopa, AZ, in 2005 and 2006. Only SJ-07P-FR03 was included in all five tests. The SJ-07P-FR01 and SJ-07P-FR02 populations were included in two and three tests, respectively, and SJ-07P-FR04 was evaluated only at the Shafter site in 2006. Tests were replicated four times in a randomized complete block design. Entries were planted in four-row plots with 1-m row spacing. Plot length varied from 12 to 15.2 m

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</table>

1^0 = no foliar symptoms; 1 = chlorosis, wilt restricted to cotyledon or first leaf or both; 2 = chlorosis or wilt extending beyond the first leaf or both; 3 = moderate to severe foliar symptoms usually with some abscised leaves; 4 = severe foliar symptoms on the entire plant; 5 = dead plant.

2^0 = no discoloration; 1 = light discoloration evident as spotty areas in the cross section of the stem; 2 = more continuous discoloration covering an area between one-quarter and one-half of the cross-section of the stem but light in color; 3 = vascular discoloration (moderate in color) evident in a band encircling almost the entire stem cross-section; 4 = vascular discoloration darker in color than in 1 or 2, and evident across most of the vascular tissue in a cross section of the stem; 5 = plant severely damaged, vascular discoloration evident throughout cross-section of the stem.

3^Parent lines.

4^Field evaluation 2003.

5^na, data not available.

6^Field evaluation 2004.

7^Kearney greenhouse evaluation 2004.

8^Kearney greenhouse evaluation 2005.

9^University of California, Davis, greenhouse evaluation 2005.

10^Cultivars used as checks.

Color in the stem tissue, number of nodes, and plant height (from the node-cotyledons to the mainstem terminal) in centimeters. Individual plants from each line were rated for disease severity based on foliar symptoms and vascular stain. A 0 to 5 scale was used for foliar symptoms, where 0 = no foliar symptoms and 5 = plant death. A 0 to 5 scale was used for vascular stain, where 0 = no vascular staining and 5 = plant severely damaged and vascular staining evident throughout a cross-section of root tissue (up to node-cotyledons region).
were good to superior compared with the SJV Pima cotton standard, PS 7 (36.7 mm and 472.7 kN m kg^{-1}) and PS 7 (36.7 mm and 472.7 kN m kg^{-1}). In 2005 at Maricopa, the more heat tolerant check cultivar, PS 7, produced significantly more lint yield (1309 kg ha^{-1}) than the SJ-07P-FR populations (SJ-07P-FR01, -FR02, and -FR03) or the more heat sensitive check cultivar, Phyto gen 800 (1112 kg ha^{-1}). However, the yield of line SJ-07P-FR03 (1082 kg ha^{-1}) did not differ from that of cultivar Phyto gen 800. In 2005, cultivar Phyto gen 800 produced a significantly higher yield (1800 kg ha^{-1}) than the evaluated SJ-07P-FR populations and the PS 7 cultivar (1717 kg ha^{-1}) at the West Side. At West Side the yield of line SJ-07P-FR03 (1591 kg ha^{-1}) did not differ significantly from that of PS 7. Depending on location and entry, the SJ-07P-FR series produced yields that were from 3 to 30% lower than the check cultivars in 2005. In 2006, in a replicated trial at Shafter, CA, lint yields were not significantly different between SJ-07P-FR02, -FR03, -FR04, and the commercial check cultivars. However, the three SJ-07P-FR lines ranked numerically lower for yield and lint percentage compared with the checks. Variability in soil composition was possibly responsible for low yields in at least two of the four replicates for SJ-07P-FR02 and -FR03. Overall, the SJ-07P-FR series showed good fiber length and strength and low-to-average lint yields, lint percentage, and fiber elongation (Table 2).

Reelection for resistance within the lines, in the presence of the pathogen, has not occurred. Evaluations were performed on generations F_{5}, F_{6}, and F_{7} that were handled as populations, and increases were performed under open-pollination conditions. In addition, field tests in different years were performed on different planting dates and under different environmental conditions, which increased the variability of results. Much is still unknown about virulence and pathogenicity of FOV race 4 in California. Recently, resistance in Pima cottons to FOV race 4 was reported to be determined by a single dominant gene and possibly one or more minors genes (Ulloa et al., 2006). However, more research is needed to determine the origin, allelic, and not allelic variation on different FOV race 4 resistance back-grounds. Users should apply caution in using these lines and should not assume that the lines provide complete resistance against FOV race 4. Additional sources (SJ-07P-FR series 01–04) for improving FOV race 4 resistance in Pima cottons should be helpful in speeding efforts to broaden the genetic base, which is a critical need of the Pima cotton industry in SJV.

**Availability**

Small quantities of seed (10–25 g) are available to cotton breeders, geneticists, and other research personnel on writ-ten request to the corresponding author. It is requested that appropriate recognition of the source be given when these germplasm lines contributes to the development of a new breeding line, hybrid, or cultivar. Genetic material of these releases will be deposited in the National Plant Germplasm System, where they will be available for research purposes, including development and commercialization of new cultivars.
Acknowledgments
The authors would like to acknowledge Dr. Roy Cantrell (New Mexico State University) for providing the original (F2) seed from which SJ-07P-FR01 to FR03 originated. The assistance of University of California Cooperative Extension Farm Advisors (Dan Munk, Fresno County; Brian Marsh, Kern County; Ron Vargas, Madera and Merced counties), Bruce Roberts (California State University, Fresno), IPM Regional Advisor Peter Goodell (University of California Kearney Agricultural Center, Parlier), and Michael McGuire (WICS RU, Shafter) is gratefully acknowledged. Special thanks for field and greenhouse project support provided by Monica Biggs, Mark Keeley, Gerardo Banuelos, John Soares, Raul Delgado, Sarah Hut macher, Anna Brown, Stan Bergen, Brian Neufeld, and James Frelichowski, from University of California County Cooperative Extension and Research and Extension Centers, and USDA-ARS, WICS RU. Access to field sites was possible with the permission and assistance of growers. Use of the greenhouse facilities of the University of California at the Kearney Research and Extension Center (Parlier, CA) and the assistance of Fred Swanson and Laura van der Staay of that center are gratefully acknowledged. Use of farm equipment and help of staff from the University of California Shafter Research and Extension Center are also gratefully acknowledged. We also thank the Cotton Foundation and the Supima Association for partial support of this study. Mention of trade names or commercial products in this article does not imply recommendation or endorsement by the U.S. Department of Agriculture, the University of California, or New Mexico State University.

Table 2. Yield and fiber data of Pima cottons for 2 yr at three locations.

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<th>Yield</th>
<th>Lint percent</th>
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<th>Elongation</th>
<th>Strength</th>
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<tr>
<td></td>
<td>kg ha⁻¹</td>
<td>%</td>
<td>%</td>
<td>kN m kg⁻¹</td>
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1 Cultivar used as check for agronomic and fiber quality characteristics.
3 NS, significant difference.
4 na, data not available.

References


